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Quantifying uncertainty in global aerosol and forcing

Ken Carslaw (1), Lindsay Lee (), Carly Reddington (), Graham Mann (), Dominick Spracklen (), Philip Stier (), and Jeffrey Pierce ()

(1) University of Leeds, School of Earth and Environment, Leeds, United Kingdom (k.s.carslaw@leeds.ac.uk, +44-(0)113-3436716), (2) University of Leeds, School of Earth and Environment, Leeds, United Kingdom, (3) University of Leeds, School of Earth and Environment, Leeds, United Kingdom, (4) University of Leeds, School of Earth and Environment, Leeds, United Kingdom, (5) University of Leeds, School of Earth and Environment, Leeds, United Kingdom, (6) Department of Physics, University of Oxford, (7) Colorado State University, USA

Aerosol-cloud-climate effects are a major source of uncertainty in climate models so it is important to identify and quantify the sources of the uncertainty and thereby direct research efforts. Here we perform a variance-based sensitivity analysis of a global 3-D aerosol microphysics model to quantify the magnitude and leading causes of uncertainty in model-estimated present-day CCN concentrations, cloud drop number concentrations and indirect forcing. New emulator techniques enable an unprecedented amount of statistical information to be extracted from a global aerosol model. Twenty-eight model parameters covering essentially all important aerosol processes and emissions were defined based on expert elicitation. A sensitivity analysis was then performed based on a Monte Carlo-type sampling of an emulator built for each monthly model grid cell from an ensemble of 168 one-year model simulations covering the uncertainty space of the 28 parameters. Variance decomposition enables the importance of the parameters for CCN uncertainty to be ranked from local to global scales. Among the most important parameters are the sizes of primary particles and the cloud-processing of aerosol, but most of the parameters are important for CCN uncertainty somewhere on the globe. We also show that uncertainties in forcing over the industrial period are sensitive to a different set of parameters than those that are important for present-day CCN.